Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots, and the very low frequency (VLF) radio recordings of SID Events in the ionosphere. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 Gnevyshev Gap, or double peak in solar cycle maximums

In 1967 Gnevyshev noticed that all the solar cycle peaks had double peaks. Some were prominent for a couple years, others shorter and more difficult to see. Here, going back to 2000, the AAVSO solar observers record three fairly distinct double peaks during the solar maximum years.

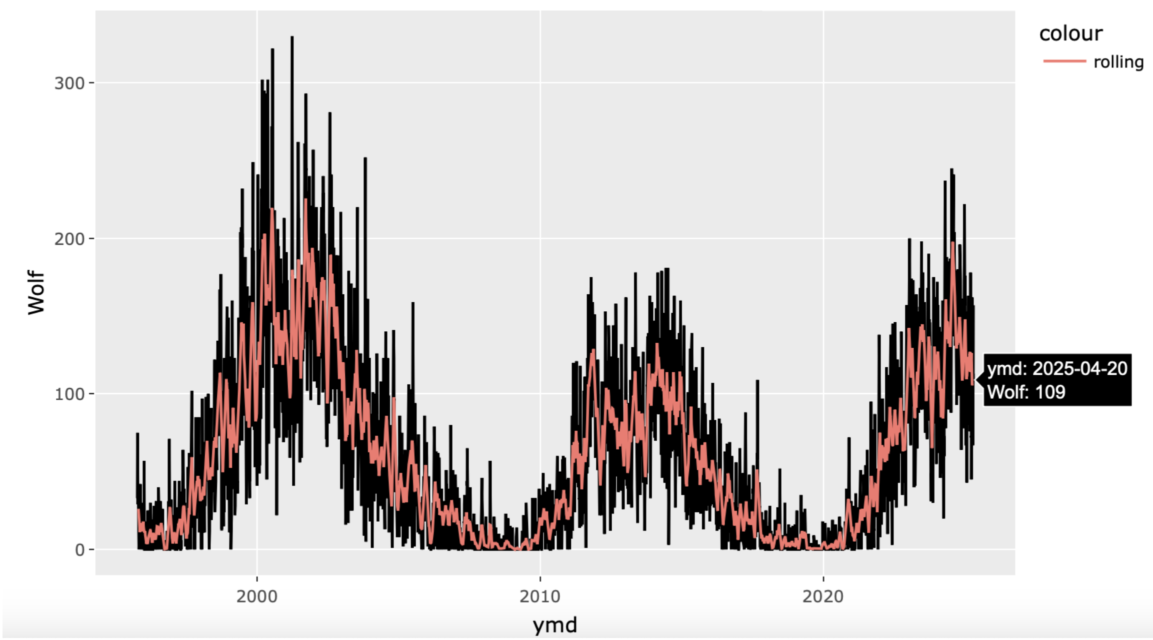

Figure 1: AAVSO: full disk Wolf numbers from 1995 - 2025

Notice the double peaks in the above plot for each of the recent solar cycles. Red denotes the North Hemisphere daily Wolf numbers and black the South.

It is a goal of many articles on this subject to identify likely causes for these double peaks. (Georgieva, 2011) likes the idea of poloidal and toroidal magnetic field lines being crossed during these double peaks. To investigate that idea we need to plot the North and South Hemisphere sunspot movement data (30-day rolling average) from our observers who use projection. This assumes the sunspot orientation is indicative of the sunspot movement from upper latitudes to the equator and follows the poloidal magnetic field lines during the peak and cancels out many active sunspot regions as the poloidal field lines cross. (See Figure 3)

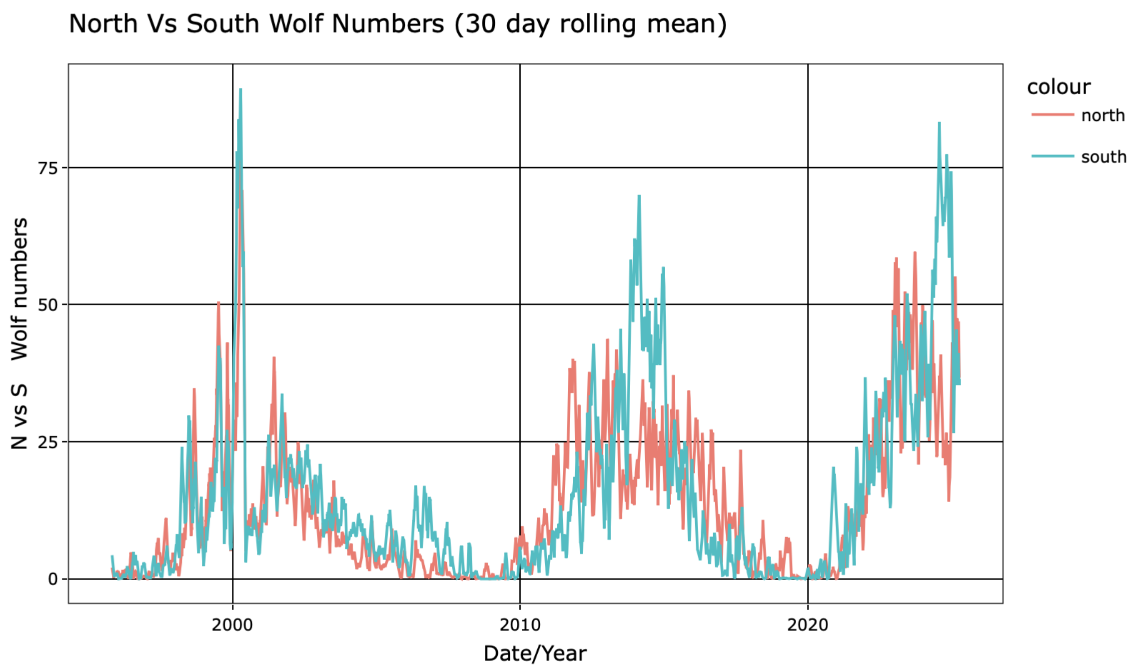

Figure 2: AAVSO, North vs South Wolf projection numbers from 1995 - 2025.

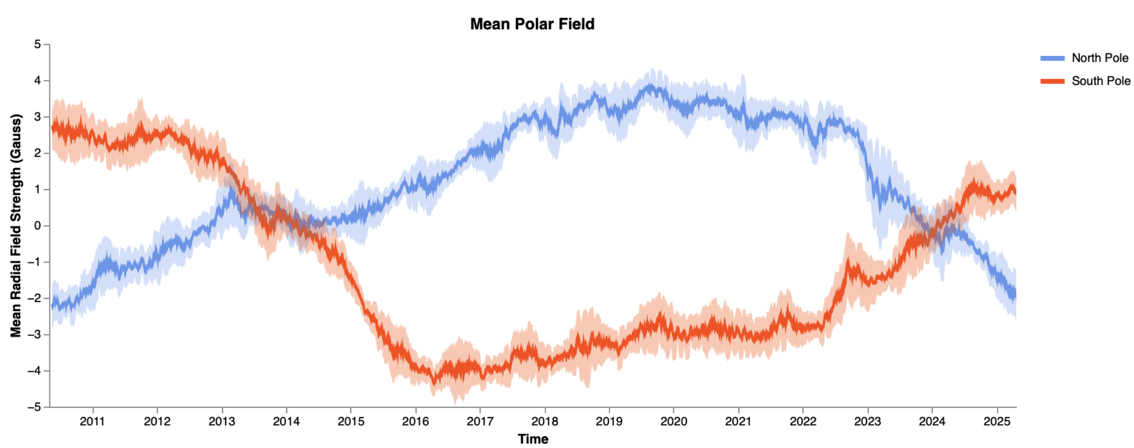

Figure 3: Here are Solar Dynamic Observatory (SDO) data from 2010 to present showing the years 2014 and 2024, where the north and south poloidal magnetic lines cross, which would be the last two solar cycle years with double peaks.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

May 2025 (Figure 4): Three M-class flares show VLF SID Events during the day for May 25, recorded by Lionel Laudet (A118).

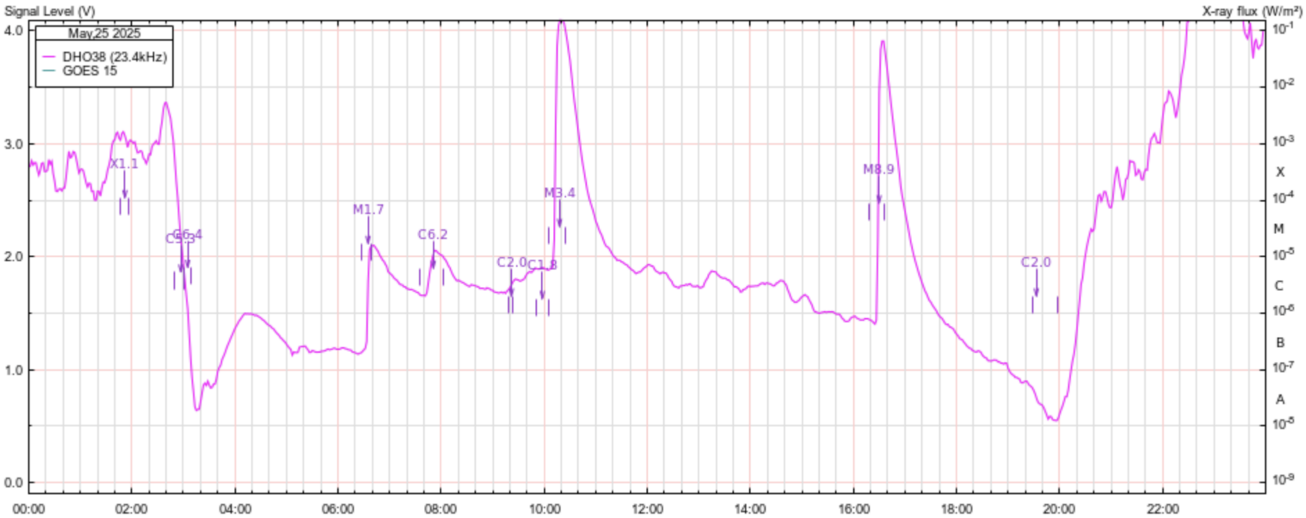

Figure 4: VLF transmitter DHO38 (22.4 kHz) from Lionel Loudet (A118) (`https://sidstation.loudet.org/data-en.xhtml`).

2.2 SID Observers

In May 2025 we had 14 AAVSO SID observers who submitted VLF data, as listed in Table 1.

Table 1: 202505 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
A Son	A112	DHO
L Loudet	A118	DHO
J Godet	A119	DHO GBZ GQD
J Karlovsky	A131	DHO
R Mrllak	A136	GQD NSY
S Aguirre	A138	NLK
G Silvis	A141	HWU NAU NLK
L Pina	A148	NAA NML
J Wendler	A150	NAA
H Krumnow	A152	DHO GBZ
J DeVries	A153	NLK
M Cervoni	A154	DHO ICV

Figure 5 depicts the importance rating of the solar events. The duration in minutes are -1: LT 19, 1: 19-25, 1+: 26-32, 2: 33-45, 2+: 46-85, 3: 86-125, and 3+: GT 125.

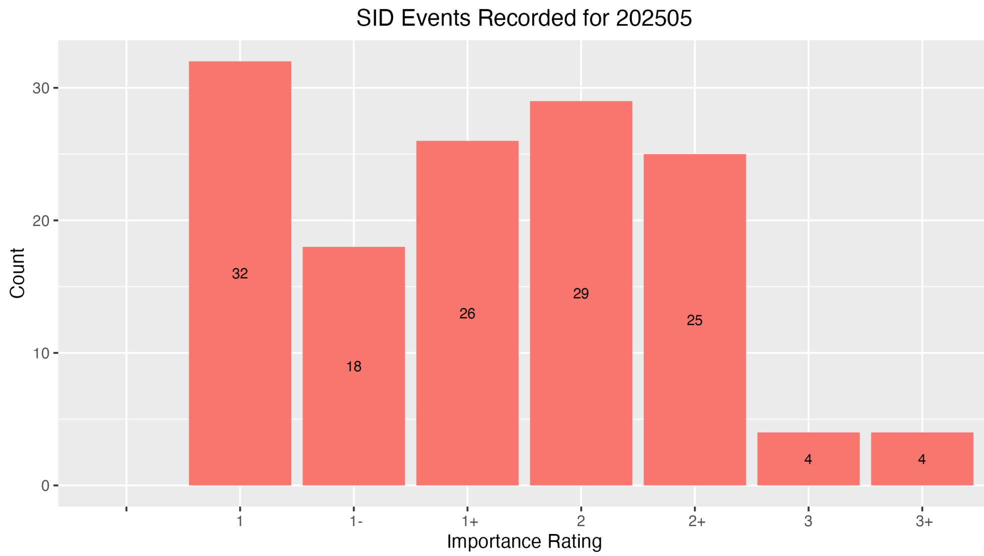

Figure 5: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In May 2025, there were 295 XRA flares: three X-class, 20 M-class, 231 C-class and 41 B-class. Lots of flaring with all four classes this month. (U.S. Dept. of Commerce–NOAA, 2024). (see Figure 6).

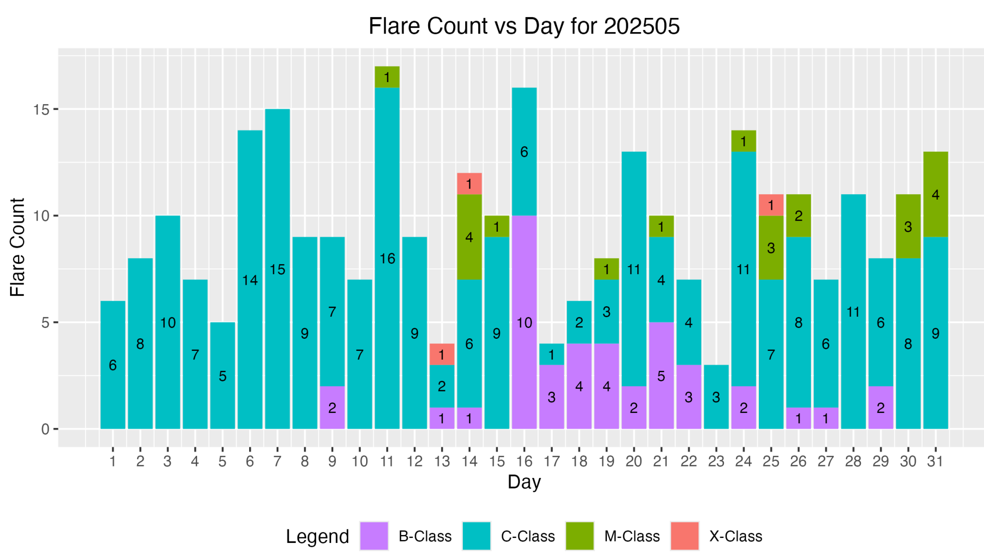

Figure 6: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2024).

3 Relative Sunspot Numbers (R_a)

Reporting monthly sunspot numbers consists of submitting an individual observer's daily counts for a specific month to the AAVSO Solar Section. These data are maintained in a Structured Query Language (SQL) database. The monthly data then are extracted for analysis. This section is the portion of the analysis concerned with both the raw and daily average counts for a particular month. Scrubbing and filtering the data assure error-free data are used to determine the monthly sunspot numbers.

3.1 Raw Sunspot Counts

The raw daily sunspot counts consist of submitted counts from all observers who provided data in May 2025. These counts are reported by the day of the month. The reported raw daily average counts have been checked for errors and inconsistencies, and no known errors are present. All observers whose submissions qualify through this month's scrubbing process are represented in Figure 7.

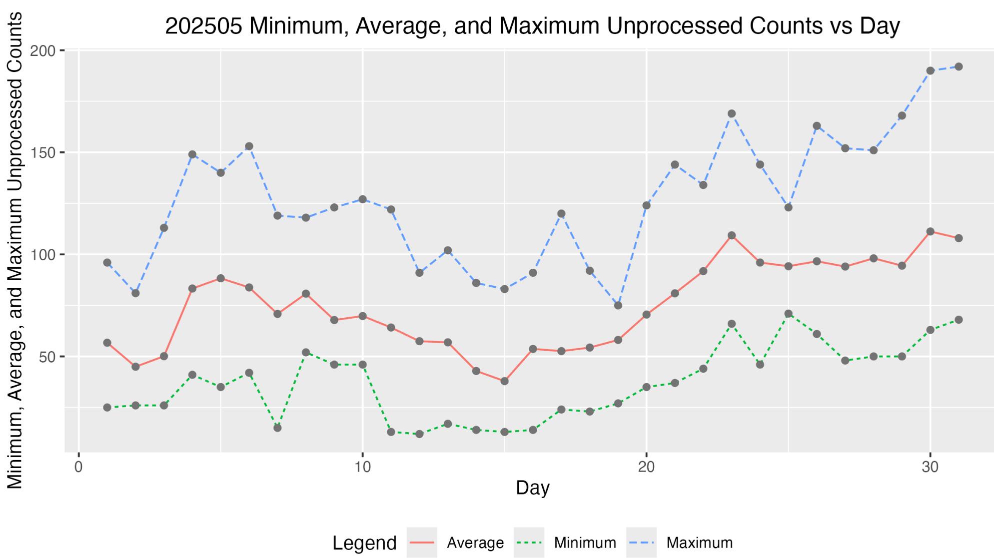

Figure 7: Raw Wolf number average, minimum, and maximum by day of the month for all observers.

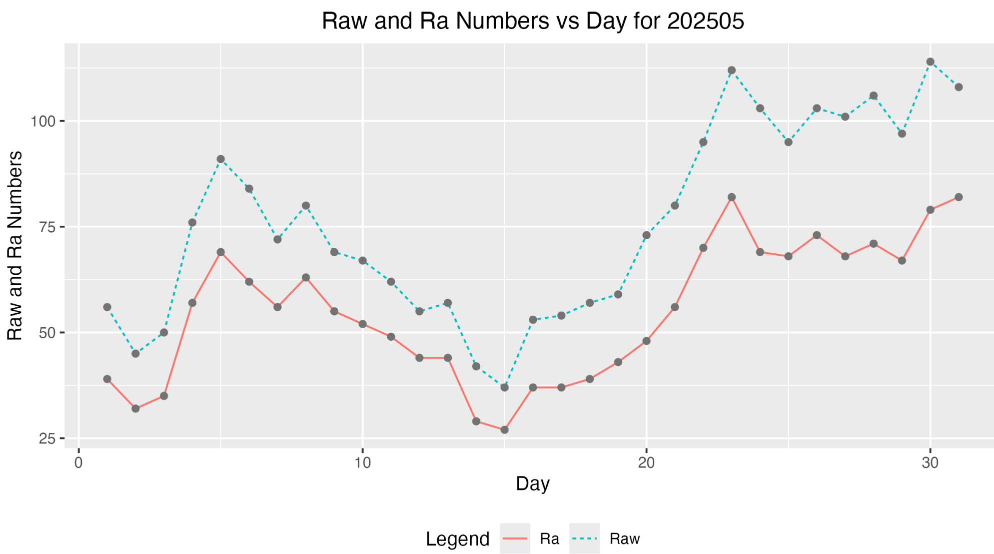

Figure 8: Raw Wolf average and R_a numbers by day of the month for all observers.

3.2 American Relative Sunspot Numbers

The relative sunspot numbers, R_a, contain the sunspot numbers after the submitted data are scrubbed and modeled by Shapley's method with k-factors (`http://iopscience.iop.org/article/10.1086/126109/pdf`). The Shapley method is a statistical model that agglomerates variation due to random effects, such as observer group selection, and fixed effects, such as seeing condition. The raw Wolf averages and calculated R_a are seen in Figure 8, and Table 2 shows the Day of the observation (column 1), the Number of Observers recording that day (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 202505 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	39	56	39
2	35	45	32
3	42	50	35
4	29	76	57
5	32	91	69
6	31	84	62
7	38	72	56
8	32	80	63
9	37	69	55
10	34	67	52
11	35	62	49
12	40	55	44
13	34	57	44
14	32	42	29
15	32	37	27

Continued

Table 2: 202505 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	37	53	37
17	36	54	37
18	35	57	39
19	33	59	43
20	38	73	48
21	30	80	56
22	30	95	70
23	36	112	82
24	34	103	69
25	36	95	68
26	35	103	73
27	31	101	68
28	32	106	71
29	35	97	67
30	36	114	79
31	39	108	82
Averages	34.7	75.9	54.9

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for May 2025, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (66), and total number of observations submitted (1075).

Table 3: 202505 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	24	Alexandre Amorim
AJV	26	J. Alonso
ARAG	31	Gema Araujo
ASA	3	Salvador Aguirre
BATR	6	Roberto Battaiola
BKL	5	John A. Blackwell
BMIG	26	Michel Besson
BTB	6	Thomas Bretl
BVZ	23	Jesus E. Blanco
BXZ	28	Jose Alberto Berdejo
BZX	24	A. Gonzalo Vargas
CIOA	5	Ioannis Chouinavas
CKB	29	Brian Cudnik
CLDB	16	Laurent Cambon

Continued

Table 3: 202505 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMAB	18	Maurizio Cervoni
CNT	16	Dean Chantiles
CVJ	1	Jose Carvajal
DARB	25	Aritra Das
DGIA	10	Giuseppe di Tommasco
DJOB	14	Jorge del Rosario
DJSA	2	Jeff DeVries
DJVA	30	Jacques van Delft
DMIB	20	Michel Deconinck
DUBF	25	Franky Dubois
EHOA	24	Howard Eskildsen
FARC	1	Arnaud Fiocret
FERA	24	Eric Fabrigat
FJOF	1	Joe Fazio
FLET	20	Tom Fleming
GCNA	4	Candido Gomez
GIGA	27	Igor Grageda Mendez
HALB	22	Brian Halls
HKY	17	Kim Hay
HOWR	21	Rodney Howe
IEWA	13	Ernest W. Iverson
ILUB	5	Luigi Iapichino
JGE	15	Gerardo Jimenez Lopez
JSI	5	Simon Jenner
KAMB	31	Amoli Kakkar
KAND	26	Kandilli Observatory
KAPJ	18	John Kaplan
KNJS	28	James & Shirley Knight
KTOC	22	Tom Karnuta
LKR	6	Kristine Larsen
LRRA	18	Robert Little
LVY	31	Doveed Levy
MARC	6	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	9	Etsuiku Mochizuki
MJHA	27	John McCammon
MLL	7	Jay Miller
MMI	31	Michael Moeller
MUDG	3	George Mudry
MWMB	3	William McShan
MWU	28	Walter Maluf
NMID	4	Milena Niemczyk
NPAB	1	Panagiotis Ntais

Continued

Table 3: 202505 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
RJV	24	Javier Ruiz Fernandez
SNE	9	Neil Simmons
SQN	23	Lance Shaw
SRIE	11	Rick St. Hilaire
TDE	17	David Teske
TST	19	Steven Toothman
URBP	28	Piotr Urbanski
WGI	4	Guido Wollenhaupt
WND	17	Denis Wallian
Totals	1075	66

3.4 Generalized Linear Model of Sunspot Numbers

Dr. Jamie Riggs, Solar System Science Section Head, International Astrostatistics Association, maintains a relative sunspot number (R_a) model containing the sunspot numbers after the submitted data are scrubbed and modeled by a Generalized Linear Mixed Model (GLMM), which is a different model method from the Shapley method of calculating R_a in Section 3 above. The GLMM is a statistical model that accounts for variation due to random effects and fixed effects. For the GLMM R_a model, random effects include the AAVSO observer, as these observers are a selection from all possible observers, and the fixed effects include seeing conditions at one of four possible levels. More details on GLMM are available in the paper, *A Generalized Linear Mixed Model for Enumerated Sunspots* (see 'GLMM06' in the sunspot counts research page at http://www.spesi.org/?page_id=65).

Figure 9 shows the monthly GLMM R_a numbers for a rolling eleven-year (132-month) window beginning within the 24th solar cycle and ending with last month's sunspot numbers. The solid cyan curve that connects the red *X's* is the GLMM model R_a estimates of excellent seeing conditions, which in part explains why these R_a estimates often are higher than the Shapley R_a values. The dotted black curves on either side of the cyan curve depict a 99% confidence band about the GLMM estimates. The green dotted curve connecting the green triangles is the Shapley method R_a numbers. The dashed blue curve connecting the blue *O's* is the SILSO values for the monthly sunspot numbers.

The tan box plots for each month are the actual observations submitted by the AAVSO observers. The heavy solid lines approximately midway in the boxes represent the count medians. The box plot represents the InterQuartile Range (IQR), which depicts from the 25^{th} through the 75^{th} quartiles. The lower and upper whiskers extend 1.5 times the IQR below the 25^{th} quartile, and 1.5 times the IQR above the 75^{th} quartile. The black dots below and above the whiskers traditionally are considered outliers, but with GLMM modeling, they are observations that are accounted for by the GLMM model.

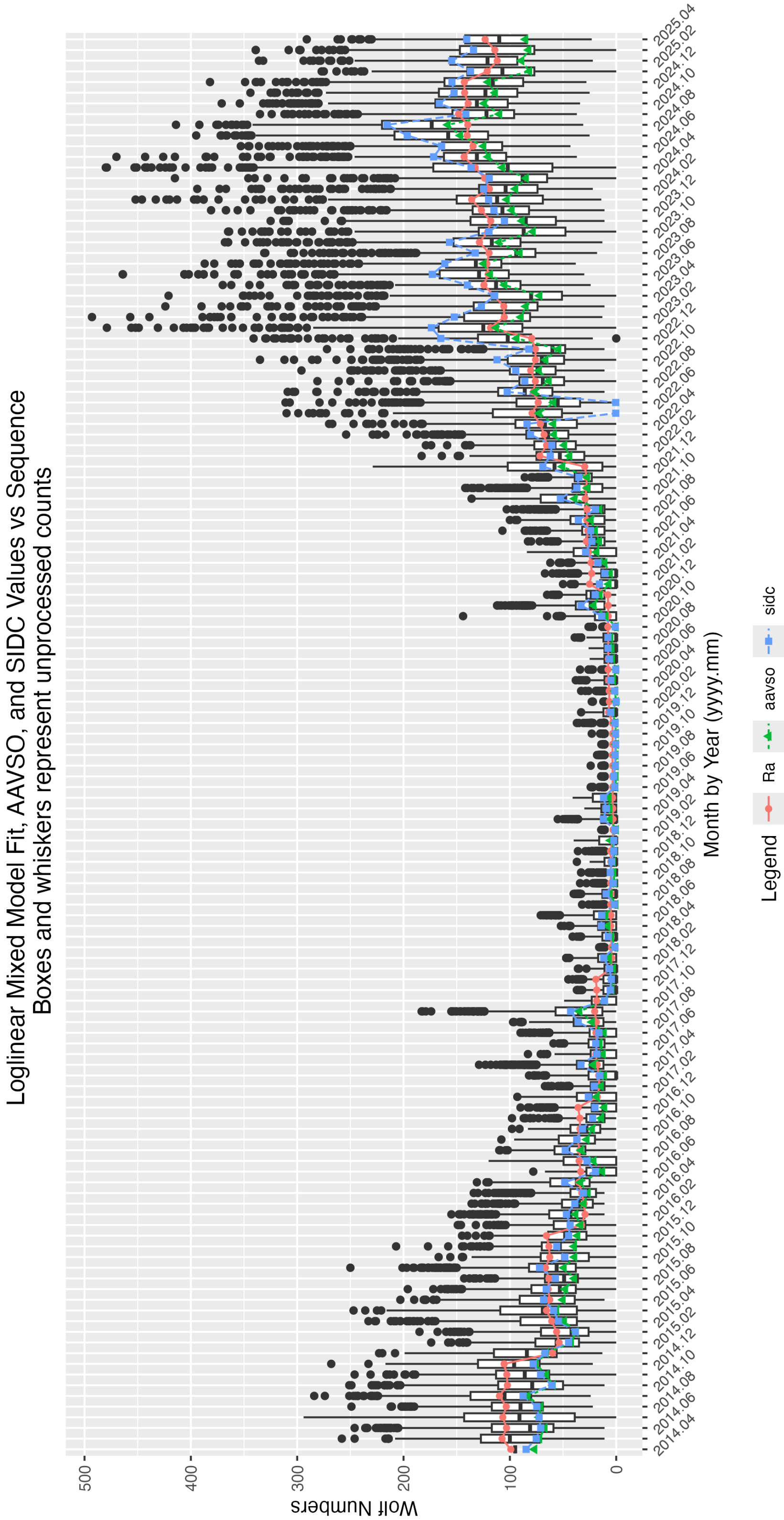

Figure 9: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe rhowe137@icloud.com

5 WSO Polar field data show Gnevyshev Gap crossover years

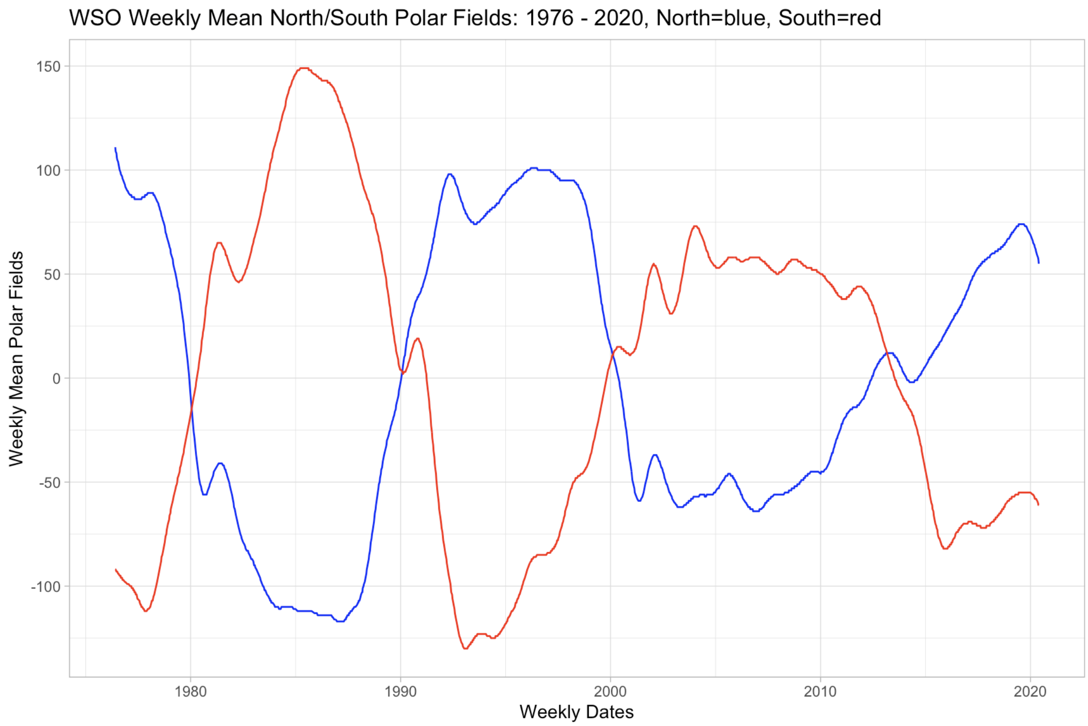

Figure 10: Wilcox Solar Observatory (WSO) has the longest record of the North/South Polar field data with Gnevyshev Gap crossovers back to 1980. (`http://wso.stanford.edu/Polar.html`)

6 References

Georgieva, K. (2011) Why the Sunspot Cycle is Double Peaked
Space and Solar-Terrestrial Research Institute, Bulgarian Academy of Sciences, 1000 Sofia, Bulgaria

Solar Dynamics Observatory (NASA)
(`https://docs.sunpy.org/projects/drms/en/latest/tutorial.html`)

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center (2024).
GOES-16 XRA data. `ftp://ftp.swpc.noaa.gov/pub/indices/events/`